LeCroy

HIGH POWER CAMAC CRATE

MODEL 1434A and 1434A MOD 100

USER'S MANUAL

Revised
Sept 1985

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ANY APPLICATION OR USE QUESTIONS, which will enhance your use of this instrument will be happily answered by a member of our Engineering Services Department, telephone 914-578-6058 or your local distributor. You may address any correspondence to:

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A T T E N T I O N

BE SURE LINKS IN FAN TRAY ARE SET FOR CORRECT OPERATING AC VOLTAGE (SEE SECTION 4.3) AND THAT THE CORRECT FUSES ARE INSTALLED (SECTION 4.4).

AC LINE VOLTAGE SHOULD BE CHECKED FOR SIGNIFICANT VOLTAGE DROPS IF UNIT IS TO OPERATE ABOVE 500 W AND SET AT 110 V AC. IF AC LINE VOLTAGE DROPS BELOW 100 V AC OR INCREASE ABOVE 120 V AC WHILE UNIT IS RUNNING ABOVE 500 W, CHANGE VOLTAGE SETTING ON TERMINAL BLOCK IN FAN TRAY TO 100 V AC OR 120 V AC RESPECTIVELY.

AC PLUG ADAPTER (RATED AT 15 AMPS) SHOULD BE REMOVED FROM POWER CORD WHEN 1434A POWER OUTPUT IS ABOVE 400 W. POWER CORD SHOULD BE INSTALLED IN AN ELECTRICAL OUTLET (WITHOUT ADAPTER) RATED FOR 20 AMPS.

SEE POCKET IN BACK OF MANUAL FOR SCHEMATICS, PARTS LIST AND ADDITIONAL ADDENDA WITH ANY CHANGES TO MANUAL.

CAMAC MODULES SHOULD NOT BE INSERTED OR REMOVED WHILE POWER IS ON. DAMAGE MAY BE CAUSED BY MOMENTARY MISALIGNMENT OF CONTACTS.

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INSTRUMENT MAINFRAMES
13-BAY BENCHTOP/25-BAY RACKMOUNT

LeCroy

1434A RACKMOUNT MAINFRAME
8013A/8013AGPIB BENCHTOP MAINFRAME

- 400/650 W Power Output
- Quality AC Line Regulation
- Self-Contained Cooling
- Thermal, Short Circuit and Over-Voltage Protection
- GPIB Compatible

INSTRUMENT HOUSINGS FOR CAMAC PLUG-INS

LeCroy Models 8013A, 8013AGPIB, and 1434A Instrument Mainframes provide housing for LeCroy's plug-in instrument modules. The 8013A benchtop series mainframes accept instruments in combinations of up to 13 single-width plug-ins. The 1434A rackmount series can accommodate up to 25 instrument modules. Both single- and dual-width plug-ins can be accommodated, providing the versatility of a single or multi-instrument modular package. Hundreds of different instrumentation packages can be configured for custom applications by using LeCroy waveform digitizers, memories, pulse and function generators, amplifiers, attenuators, ADC's, time interval meters, counters, trigger generators, and even fiber optic links.

FEATURES

High Output Power—650 W for 1434A, 400 W for 8013A

Operates from Standard Line Voltage—110 V AC or 220 V AC operation

Versatile Modular Design—Modularity allows the maximum performance for the application.

Easy System Upgrading—Modularity also allows easy upgrading to take advantage of technology.

GPIB Compatible—Programmed automation and control via GPIB interface option.

Short Circuit Proof—Instrument mainframes are current limited and contain overload detectors for automatic shutdown.

Instrumentation Quality Regulation—Line and load regulation for AC line changes and for load changes.

FUNCTIONAL DESCRIPTION

Versatility, user customization, and expandability are the prime advantages of LeCroy mainframes. Many more functions than could be practically or economically combined in a single instrument are available by selecting the appropriate LeCroy instrument and accessory modules. This plug-in modular design permits the user to meet changing needs and allows for system upgrading with new instrument module releases from LeCroy.

LeCroy's low cost modular customization and easy upgrading concepts are enhanced by the Model 8901A GPIB interface option. This mainframe accessory (included in Model 8013AGPIB) provides an IEEE-488 Standard Interface to the Models 8013A and 1434A Instrument Mainframes. Thus, remote control, data transfer, and simple program instruction of LeCroy instrument modules can be achieved using the user's host controller. A system consisting of a LeCroy Controller (Model 6010), digitizer, and user supplied RS-232 terminal offers complete automation of many measurements.

Both instrument mainframes offer the standard ±6 V and ±24 V supplies for LeCroy and other standard CAMAC modules. The high power Model 1434A, with 650 W of continuous power, has ±6 V outputs to supply a total of 90 A, with either the +6 V or −6 V supplies capable of 60 A via internal selection. In addition, the Model 1434A offers an optional ±12 V supply to provide up to 3 A for both +12 V and −12 V. A built-in digital multimeter on the front panel of the 1434A provides convenient monitoring of all voltage and current outputs.

LeCroy instrument mainframes operate from standard 50/60 Hz, 110/220 V AC power. Instrument quality line regulation, long term stability, and load regulation assure reliable trouble-free operation of inserted modules. Models 8013A and 1434A are current limited and have overload protection for short circuits. Automatic overtemperature sensing shuts down the 1434A supply in the event of a thermal overload and indicates a fault. The Model 8013A has the additional feature of a short term (16 msec) uninterruptible power supply to guard against brief power line interruptions.

These instrument mainframes have been designed for user convenience and serviceability. Low insertion force connectors and quality guides are used to ensure proper mechanical alignment and ease of module installation. The Model 1434A offers a servicing feature of in-rack accessibility to the power supply and fan assembly. The two instrument mainframes provide good air flow and ventilation through forced cooling by high capacity, quiet fans.

Both Models 8013A and 1434A Instrument Mainframes meet all requirements of the CAMAC Standard (IEEE-583), assuring unrestricted choice of modules from LeCroy or second-source CAMAC suppliers.

SPECIFICATIONS

Model 1434A
HIGH POWER CAMAC MAINFRAME

Module Capacity: 23 single-width plus one dual-width controller.

Dimensions: 19″ rackmount, 12¼″ height, 22½″ depth.

Voltage Meter: 3½ digit meter provides monitoring of all output currents and voltages. Accuracy ±1% of full scale voltage; ±2% of full scale current. Resolution better than 0.5%.

Cooling: Six high capacity fans.

NOTE: The Model 1434A must be mounted in such a way that the air circulation through the Crate is not impeded.

Weight: 47 lb. (21.5 kg)

Model 1434AP
Power Supply included in the Model 1434A

CONDITIONS: Line voltage 110 V, transformer wired for 110 V, ambient temperature 25°C.

POWER AVAILABLE

Total Power: 650 W maximum ±6 V, ±12 V, ±24 V combined.

Maximum output currents from:
±6V Up to 60 A from either supply. 90 A maximum combined sum. Factory set: 45 A maximum from +6 V, 60 A maximum from −6 V. Reversible by user. See graph 1 for load conditions.
±24 V 6 A maximum each. Subtract current drawn by ±12 V load.
±12 V 3 A maximum each derived from ±24 V supply.

PERFORMANCE

Ripple: <2 mV RMS (10 kHz bandwidth), <5 mV peak-to-peak (50 MHz bandwidth).

Regulation: ±0.01% line or load (measured at the sense leads).

Temperature Coefficient: <100 ppm/°C.

Long Term Stability: <0.1%/24 hours at constant load and temperature. Measured after 1-hour warmup.

Response Time: Settles to within 1% of final value in less than 100 μsec for 10% to 100% load change.

Tracking: During turn-on all six output voltages rise together. Risetime 10 msec.

GENERAL

Overload Protection: All outputs are protected against overload by current limit circuit, factory set to 7% above maximum allowable output current; short circuit proof. All outputs switch off within 20 msec of detected overload.

Overvoltage Protection: All outputs are protected against transient overvoltages by high current transient suppressors. Any sustained overvoltage >1.5 V will turn off all outputs within 20 msec.

Thermal Protection: A thermal sensor shuts down the supply in the event of a thermal overload. A front-panel thermal overload light on the fan tray indicates an over-temperature condition in the power supply. Remote indication of an overload is provided via an open collector TTL signal on a front-panel mounted BNC connector.

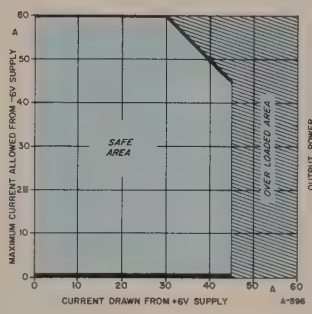
Automatic Power Reset: A jumper option in the fan tray activates a relay which automatically turns the crate back on when power is restored after an AC power failure related shutdown.

Operating Range: Full 650 W output from 0°C to 40°C ambient temperature. Derate at − 10 W/°C. above 40°C. Maximum ambient temperature 50°C. See graph 2.

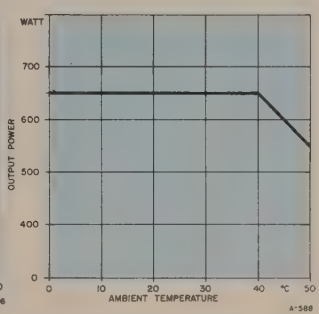
Line Voltage: Field Selectable: 100/110/120/200/220/240 V AC ±10%, 47 to 65 Hz. Factory set to 110 V. 220 V operation recommended if full output power is permanently needed.

Line Current: 18 A RMS at 110 V and full output power, 9 A RMS at 220 V.

Weight: 53 lb. (24.1 kg)



GRAPH 1



GRAPH 2

Model 8013A
CAMAC BENCHTOP MAINFRAME

Module Capacity: 11 single-width plus one dual-width controller.

Dimensions: 14″ H x 11.5″ W x 18.7 ″ D

Cooling: Plug-in compartment thermally isolated from power supply. Two fans provide bottom to top positive airflow. Unit should be operated on a flat surface to prevent blockage of air inlets for fans.

POWER AVAILABLE

	+6 V	−6 V	+12 V	−12 V	+24 V	−24 V
8013A:	23 A	23 A	—	—	2.5 A	2.5 A

Total Power: 400 W max, ±6, ±24 V combined, all supplies independent

PERFORMANCE

Ripple: <50 mV p-p (50 MHz bandwidth)

Line Regulation: ±0.5% for line changes within operating limits

Load Regulation: ±0.5% for no load to full load changes (±24 V) <±2% for no load to full load changes (±6 V)

Temperature Coefficient: <100 ppm/°C

Long Term Stability: <0.1%/8 hour constant load and temperature after 1 hour.

Response Time: Settles to within 1% of final value in less than 500 μsec for 50%-100% load change

(Continued)

GENERAL

Overload Protection: Current limit circuit; short circuit proof. Outputs switch off within 20 msec of overload.

Energy Storage Time: 16 msec holdup after AC power loss.

RFI: Via power line interference filter. Conducted and radiated RFI significantly reduced.

Operating Range: 15°C to 35°C operating; – 10°C to 50°C storage

Input Voltage Requirements: 85 to 135 V AC; 170 to 270 V AC, 47-65 Hz

Weight: 40 lb. (18 kg)

ORDERING INFORMATION

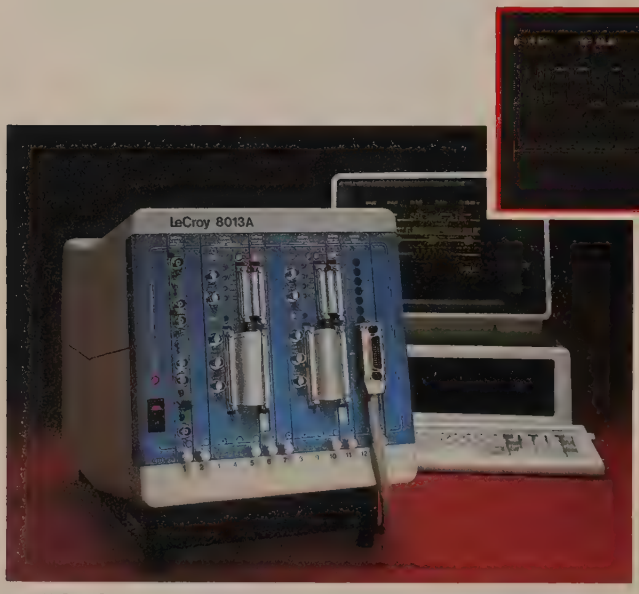
Model No.	Description
1434A	Complete 25-position Mainframe Assembly. Includes Supply and Fan Tray
8013A	13-position Benchtop Mainframe
8013AGPIB	11-position Benchtop Mainframe with LeCroy Model 8901A GPIB interface

WAVEFORM-CATALYST™

LeCroy Modular Waveform Digitizers and associated memory modules are fully compatible with LeCroy's WAVEFORM-CATALYST, a multi-channel digital oscilloscope with powerful capabilities for acquisition, display, storage, and analysis of high-speed waveforms. WAVEFORM-CATALYST is an integrated system consisting of modular waveform digitizers, any of the IBM™ personal computers (PC, Portable, XT or AT) and system WAVEFORM-CATALYST software.

LeCroy offers other accessory modules such as dual channel amplifier/trigger generators (Model 6102 100 MHz manual and Model 6103 150 MHz programmable). Also available are various clock, time and gate generator modules. Please call our application engineering staff for further information.

All programmable waveform recorder parameters can be set or read and the recorded data can be read by a controller or a computer. This may be accomplished via any mainframe interface such as the LeCroy Model 8901A or 6010 GPIB (IEEE 488) Interface. Other interfaces compatible with the CAMAC (IEEE 583) Standard may be used.



AN IBM PC with the WAVEFORM-CATALYST package can control up to 15 CAMAC mainframes linked via the GPIB IEEE-488 bus.

LeCroy Recorders in high power CAMAC mainframe linked by GPIB IEEE – 488 Bus

LeCroy

innovators in instrumentation

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SECTION 1

SPECIFICATIONS

1.1 See Technical Data Sheet

1.2 Additional Specifications of 1434A Subassemblies

The 1434A CAMAC Power System consists of the Model 1434A Crate, the Model 1434AF Fan Unit and the Model 1434AP Power Supply. The Model 1434A Crate utilizes the Berkeley approved Dataway, low insertion force connectors and precision cast runners for 25 module positions. Two guide pins and four captive screws are provided for mounting the 1434AP Power Supply onto the crate. A 50-pin connector at the end of a 12-inch cable supplies power to the crate.

The Power Supply ON-OFF switch, overload shut-down circuit and metering circuitry are contained within the Model 1434AF plug-in Fan Assembly which slides into the bottom 3.5 inches of the Model 1434A Crate. Electrical connection is made to the 1434AP Power Supply via a signal connector and a power connector. The Fan Assembly contains six 127 CFM fans which are used to cool the modules in the crate. A flush-mounted filter can be removed without disturbing the Fan Assembly. The foam air filter can be cleaned by running water through it.

Since the Fan Assembly plugs in, the Power Supply can be removed from the rear of the CAMAC Power System without disturbing front-panel wiring.

Additional features of the CAMAC Power Supply System include:

a. A 25 A solid-state relay switches the AC power input. The ON-OFF switch activates an auxiliary 5 V supply that powers the automatic shutdown control.

b. Crate cooling is independent of the Power Supply cooling. Nine 127 CFM fans are used in the system. Six fans cool the crate and three fans cool the power supply heat sink assembly.

c. A $\pm$12 V regulator is provided. Three amps are available from each side. Current drawn from this regulator must be subtracted from the $\pm$24 V current capability.

d. A jumper option in the fan tray activates a relay which automatically turns the crate back on when power is restored after an AC power failure related shutdown.

e. A connector is provided adjacent to the AC power cord which permits $\pm$24 V and $\pm$6 V to be monitored.

f The regulators for the four CAMAC standard ($\pm$24 V and

±6 V) and the optional ±12 V power supplies are contained on a single printed circuit board. Voltage adjustment potentiometers allow variation of output voltages by at least ±2%.

g. Overvoltage protection is provided on all outputs.

h. All voltages incorporate overcurrent protection. The supply will shutdown in the event of a current overload or a continuous short circuit condition. Thermal warning and thermal cutoff switches are provided to protect the power supply should the internal temperature exceed safe limits. BNC connector on the front panel is held at TTL high level under normal operating conditions and clamps to TTL low level to assert a thermal warning. This output can also be used to indicate that the power supply is in its overload shutdown condition by operating an internal switch.

i. Input Current for 110 V AC:
(650 W output)
Average 12.6 A
RMS 17.8 A
Peak 37 A

1.3 1434A MOD 100

The 1434A MOD 100 has vents in the base of the fan tray to provide vertical air flow for use in externally cooled rack systems. The front-panel air intake on the fan tray is blocked off on the 1434A MOD 100.

SECTION 2

OPERATING INSTRUCTIONS

2.1 Installation and Output Monitoring

The CAMAC Power System is delivered ready for use at the 110 V AC (factory set) supply voltage. To use it at a different voltage see Section 4.3. The power supply usually is shipped in a separate box. The user should mount it on the crate by plugging in the 50-pin connector, pushing the power supply onto the two guide pins and screwing in the four 10-32 screws which hold the power supply on the crate. The crate is usually shipped with the fan tray already inserted (mounted onto the crate with two front-panel thumb screws) so user installation of this subassembly is not necessary. The AC cable should be plugged into an outlet and the ON-OFF switch on the front panel turned on. The unit is then operable. The digital meter on the front panel will display the output voltage or current of the supply selected by the meter switch.

Connecting DC power and the inserting and removal of modules from the Bin should be done only when the AC Power Switch is "OFF".

Circuits for monitoring the current outputs of the $\pm$6 V, $\pm$12 V and $\pm$24 V supplies are calibrated at the factory to an accuracy of $\pm$ 2% of full scale. The voltage calibration is preset by high stability 1% resistors and is not adjustable.

A connector located adjacent to the AC receptacle provides a convenient means of monitoring the four standard output voltages, i.e. $\pm$24 V and $\pm$6 V.

2.2 Overload and Short Circuit

Overload protection is provided by a current-limiting circuit which operates when the current exceeds the normal rating of the supply.

The current limiting circuit has a foldback characteristic which causes the current limit to be reduced when the output is shorted.

If the overload persists for more than 2 msec the automatic shutdown circuit will be triggered and will switch off all six output voltages. Power can be restored by turning the ON/OFF switch off for about 20 sec then turning it on again. If the condition that caused the shutdown is still present the supply will immediately shutdown again.

2.3 Overvoltage

Overvoltage protection is provided for all six outputs by

TranZorbs (tm) which clamp the outputs at voltages approximately 1 to 1.5 V greater than normal. The TranZorbs protect the system to which power is being supplied from excessive voltage due to power supply failure, wiring error, or high voltage transients. If a TranZorb operates because of power supply failure, and the current-limiting circuitry is inoperative, excessive AC current will be drawn and the AC fuses will open.

2.4 Voltage Adjustment

Voltage adjustment potentiometers are located at the top of the power supply. They permit a minimum adjustment of $\pm$2% of the supply's nominal value for all six voltages.

Power supply regulation and ripple voltages should be measured at the voltage sense leads which are available at the Power Supply PG26 connector for all six voltages.

2.5 Thermal Overload

Four thermal switches are mounted on the power transistor heat sink to protect the Power Supply against thermal overload. The warning switch will close at 220 $\pm$10°F (approx. 104°C), and the breaker switch will open at 250 $\pm$10°F (approx. 121°C). The warning switch is used to indicate the thermal overload condition. If it is not corrected, the breaker switch will shut down the AC input power to the Power Supply.

SECTION 3

PRINCIPLES OF OPERATION

3.1 General

The schematic diagram (in rear pocket of manual) shows the interconnections between the Model 1434A CAMAC Crate and CAMAC Power Supply Model 1434AP. In addition, interconnections between the power input, the transformer, rectifier, filter, regulator circuitry and monitoring circuit are shown. The AC input is fed via a three-wire cord, through two slow-blow fuses.

Transformer T1 is used to provide power for all power outputs. In each case, a full wave rectifier is used with filtering, which provides a maximum of 10% ripple at the input to the power transistors and regulator circuits.

Regulator circuits for the all six voltages are located on the regulator printed circuit board in the power supply. This board also contains the trimming potentiometers for each supply. This board can be reached by removing the Power Supply cover.

Rectifiers for the $\pm$6 V and $\pm$24 V supplies are located on a heat sink above the transformer.

The power transistors are mounted on a fan-cooled heat sink assembly. The current passing through each of the output transistors is fed via current sensing resistors located on the heat sink to the output connector.

The TranZorbs which provide the overvoltage protection are located on the regulator board except for those protecting the $\pm$6 V supplies which are mounted on the heat sink assembly.

Capacitors are used at the output of each of the regulators to reduce high frequency noise, and also provide a frequency corner which permits the power regulator circuitry to be operated in a stable mode.

The current-limiting circuit provided in each of the regulators is the fold back type. These circuits will limit at currents in excess of the nominal current rating of the supply and will then fold back and reduce the amount of current drawn. The Power Supply will shut down if the excess current persists.

All six supplies use a common reference source which is buffered and inverted by two low-drift amplifiers to provide reference voltages of +5.0 V and -5.0 V. On turning on the supply, the reference voltage and hence the output voltages rise together with an RC time constant of 3.3 msec.

The shutdown circuit is powered by an auxiliary +5 V supply located in the fan tray. The ON/OFF switch controls this supply.

3.2 Voltage Regulators ±6 V

The nominal ±6 V supply provided by the main transformer, rectifiers and reservoir capacitor bank is stabilized by positive and negative series pass regulators to provide the plus and minus 6 V supplies.

The positive and negative regulators are identical except for the reversed polarity of all the semiconductor devices used, so it is not necessary to describe the operation of both in detail. Each series regulator comprises two parallel high current transistors (Q2P, Q2N). They are situated on two separate heat sinks to share the thermal load equally. Resistors (R1P, R2P, R1N, R2N) act to share the current equally between the two transistors and also provide a voltage drop that enables the load current to be measured.

The bases of the series regulator transistors are driven by a Darlington transistor (Q1P). This permits the output voltage to be controlled by an input of a few mA. This current comes from a current source (Q2P, on the control board 1434AP-1). The drive voltage to Q1P on the heat sink and hence the output voltages are controlled by draining a variable amount of current through Q1P on the regulator board. Since this transistor has an emitter resistor and sees a collector resistance made up of the input resistance of the output stages in parallel with R28, it acts as a voltage amplifier Its collector voltage, and hence the output voltage, is limited by the zener diode (CR9).

Q1P on the regulator board is driven by a low drift amplifier (U2) which compares the reference voltage with a fraction of the output voltage. C11 provides a dominant pole to ensure the AC stability of the supplies under normal operating conditions.

Protection against excess load current is provided by a foldback current limiter Q3P which clamps the output current to a maximum of 60 A and reduces the load current to about 30 A under short circuit conditions. Neither of these conditions should damage the power supply. To avoid damage to the equipment driven by the supply, however, an overcurrent detector, optocoupler, U6 causes the AC power to the entire supply to be cut off within 20 msec of an overcurrent or short current. Transient overloads, of less than a millisecond, should not trigger a shutdown.

In the event of the short-circuit failure of either of the series pass transistors, the output voltage is clamped to 7.5 V by a TranZorb. This creates an overload current which triggers the shutdown circuit.

If both series pass transistors were to fail to open circuit the control amplifier would shut off Q1P in an attempt to restore the output voltage. This condition is also detected and is used to shut off AC power to the supply.

In addition, if the heat sink on which the series pass transistors are mounted becomes too hot for their continued safe operation the supply will shut off. Advance warning of overheating is given both visually and electronically, enabling the user to reduce the load or to check for problems such as an obstructed air flow.

In all cases, if the supply shuts down, a front-panel warning light indicates the fault condition. If the fault was a transient one, normal operation can be restored by switching off and on again. If the supply immediately shuts off again the fault is still present and should be traced.

If for any reason the shutdown circuit should fail to operate correctly, the increase in AC input current should blow the AC input fuses before permanent damage is done to the power supply.

DC power supplies of this type commonly use crowbar circuits and DC fuses to protect the connected equipment and the supply from excessive voltages and currents. Neither is fitted in this supply. The shutdown circuit operates more rapidly than a fuse and cuts off all six supplies, thus avoiding equipment damage that could result from the failure of only one supply rail. The TranZorbs used to provide overvoltage protection are inherently more reliable than crowbar circuits and have an instant limiting effect rather than the time delayed clamping effect provided by a crowbar. They are also immune to nuisance triggering, a problem with crowbars that is exacerbated by the need to replace fuses.

The TranZorbs behave as high current diodes in the reverse direction and thus protect the power supply from reverse current transients generated by the load.

3.3 Voltage Regulators ±24 V

The ±24 V regulator circuit is identical in operation to the ±6 V regulator apart from the configuration of the series regulator transistors and some of the component values. Each supply uses two parallel connected Darlington transistors to control the load current. Similar overvoltage and overcurrent protection is provided.

3.4 Voltage Regulators ±12 V

The ±12 V output current is derived from the ±24 V supplies and is regulated by single Darlington transistors. Overvoltage protection is provided, but the overcurrent circuit of the ±24 V supply is used to provide overcurrent limiting and shutdown. Thus up to 7 A can be drawn from the ±12 V rails without triggering a shutdown, but the 3 A rating should not be deliberately exceeded.

SECTION 4

MAINTENANCE

4.1 Ordering of Parts

The Parts list contained in the rear pocket has a list of all electronic parts and has a nine digit number for each which may be referenced when ordering parts from the factory.

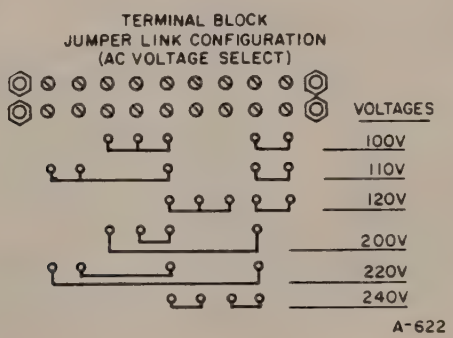
4.2 Adjustments

The voltage adjustments are located on the printed circuit board inside the 1434AP power supply. These potentiometers can be located by reference to the schematic sheet contained in the back pocket of this manual.

4.3 Selecting the AC Supply Voltage

This power supply can be set to operate from 100, 110, 120, 200, 220 and 240 V AC (all ±10%). It is shipped set to the most common supply voltage at its destination. Most supplies are factory set to operate on 110 V AC. If the supply has been set for a different operating voltage, a sticker on the front panel indicates the setting.

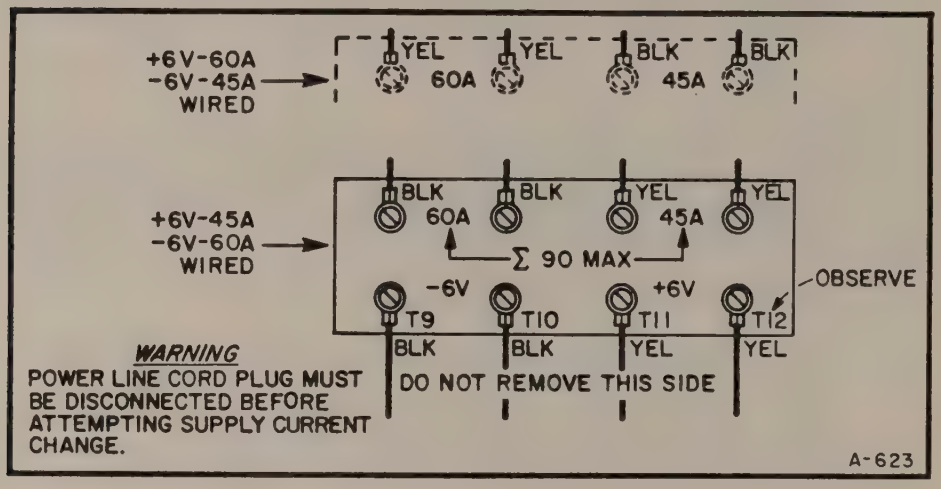
The operating voltage is set by three jumper links in the fan tray. This setting can be changed by changing the positions of the links according to the table below.



Remove the original voltage sticker. Replace the original fuses with ones suited to the new voltage setting. See following section.

4.4 ±6 V Line Current Change

For ±6 V line current change from factory setting of 60 A at -6 V and 45 A at +6 V refer to the illustration below.



4.5 Fuse Replacement

To ensure the safe operation of this supply it must be fitted with appropriate AC fuses.

SIZE	1/4" X 1 1/4"	
TYPE	SLOW BLOW	
VOLTAGE RATING	125 V and 250 V	
CURRENT RATING	15 A	200,220,240 V AC
	25 A	100,110,120 V AC

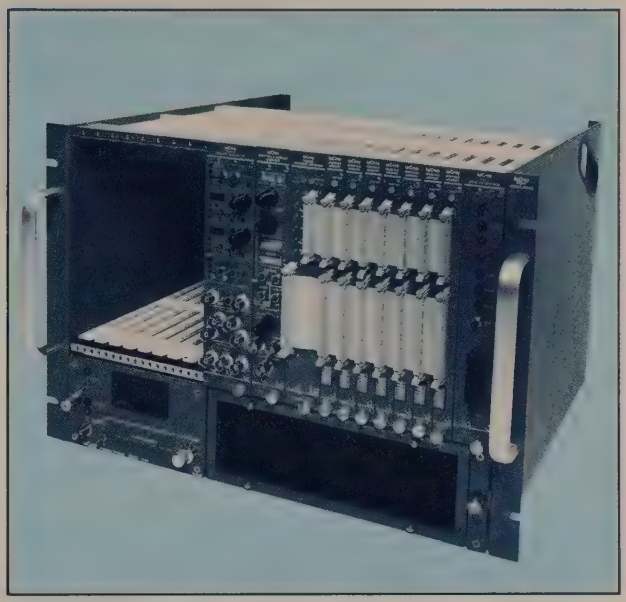
RECOMMENDED TYPES

LITTELFUSE	326 025	(25A)
BUSS TYPE SPT	MDA15	(15 A)
LITTLEFUSE	255.500	(1/2 A)

APPLICATION NOTE

LeCroy

AN-33 INTRODUCTION TO CAMAC



Full power Crate with GPIB interface and waveform digitizer.

CAMAC is a modular data handling system used at almost every Nuclear Physics research laboratory and many industrial sites all over the world. It represents the joint specifications of the US NIM and the European ESONE Committees.

The primary application is data acquisition but CAMAC may also be used for remotely programmable trigger and logic applications (LeCroy ECLine family of programmable logic units). The CAMAC standard covers electrical and physical specifications for the modules, instrument housings or crates, and a crate backplane. Examples of crates include the LeCroy Model 1434A with 25 positions and the Model 8013A with 13 positions.

Individual crates are controlled by slave or intelligent controllers such as the LeCroy Model 4801. The controllers are tied together with a parallel Branch Highway that ends in a Branch Driver. The Branch Driver is interfaced directly to a data acquisition computer. Alternatively, tree or parallel data acquisition architectures may be created by connecting secondary CAMAC branches via an intelligent, programmable CAMAC Branch Driver Module, the Model 4805. This unit would reside in a crate on the primary CAMAC branch. See application note AN-35 for examples.

CAMAC crates may also be connected in a Local Area Fiber Optic Network via the LeCroy Model 5211 Fiber Optic Serial Link and a serial crate controller. Up to 62 crates separated by a maximum of 500 m can exchange data at transmission rates of 45 megabytes/sec.

LeCroy also offers crate controllers that interface directly with the GPIB or IEEE Std 488-1978 Bus. Therefore an entire CAMAC Crate may appear as a single instrument on this very popular laboratory instrument bus. The Model 8901A is a GBIP/CAMAC slave interface that operates as a "Talker/Listener" while the Model 4802 may be programmed to do computations and data compaction.

Timing and protocol specifications permit up to 1 megaword/sec transfers of 16 or 24-bit words for both the DATAWAY and CAMAC Branch. GPIB timing is usually limited by the host computer and typically runs at 500 kilobytes/sec.

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SECTION 1: INTRODUCTION

CAMAC is an international standard of modularized electronics as defined by the ESONE Committee of the JRC, Ispra. Its function is to provide a scheme to allow a wide range of modular instruments to be interfaced to a standardized multi-receptacle which, in turn, may be interfaced to a computer. In this way, additions to a data transfer and control system may be made by plugging in additional modules and making suitable software changes. Thus, CAMAC allows information to be transferred into and out of the instrument modules.

CAMAC modules may be plugged into a CAMAC Crate which has 25 *STATIONS*, numbered 1 through 25. Station 25, the rightmost station, is reserved for a CRATE CONTROLLER, whereas Stations 1 — 24 are *NORMAL STATIONS* used for CAMAC Modules (see figure below). Usually, Station 24 is also used by the controller in that most controllers are double width (#2 CAMAC). The purpose of the controller is to issue CAMAC *COMMANDS* to the modules and transfer information between a computer (or other digital device) and the CAMAC modules.

Data transfer, control functions, and module powering is affected via the *DATAWAY*. This is a series of bus and individual lines across the back of the crate. The DATAWAY lines include digital data transfer lines, strobe signal lines, and addressing lines and control lines. See Table 3 for a pin allocation chart.

In a typical DATAWAY operation, the crate controller issues a CAMAC *COMMAND* which includes specifying a station number (N), a subaddress (A), and function code (F) (see Table 1). In response, the subaddress of the module will generate valid command accepted (X response) and act on the command. If this command requires data transfer, the read (R) or write (W) lines will be used. Note that the terms Read and Write apply to the controller, not the module. For example, under a Read command, the controller reads data contained within a module.

SECTION 2: USE OF THE DATAWAY LINES

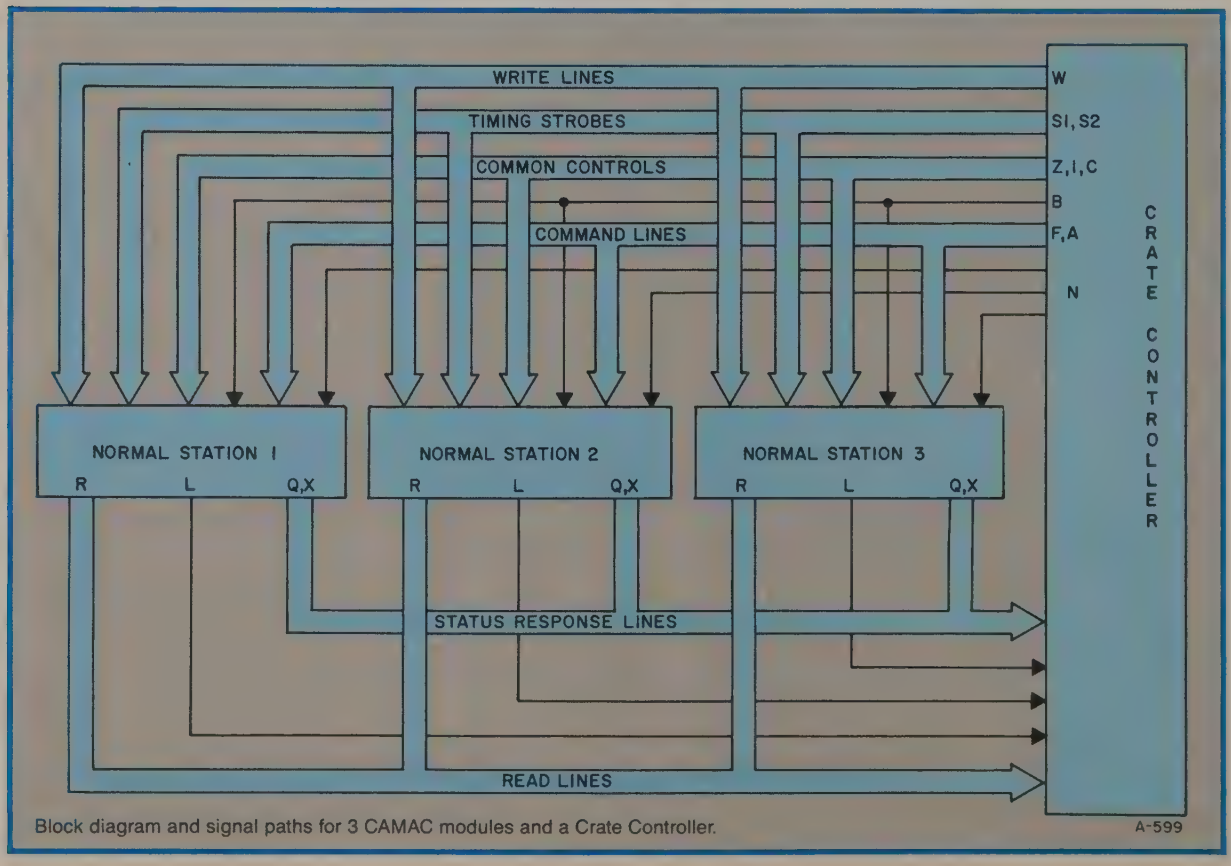
Communication with plug-in units takes place through the DATAWAY. This passive multi-wire highway is incorporated in the crate and links the 86-pin sockets to all stations. The bus lines link corresponding pins at all normal stations and, in some cases, the control station. Individual lines link one pin at a normal station to one pin at the control station. The patch pins have no specified DATAWAY wiring but can be connected to individual points to which patch leads may be attached.

During a DATAWAY operation the controller generates a command consisting of signals on individual Station Number lines to specify one or more modules, signals on the Subaddress bus lines to specify a sub-section of the module or modules, and signals on the Function bus lines to specify the operation to be performed. The command signals are accompanied by a signal on the Busy bus line, which is available at all stations to indicate that a DATAWAY operation is in progress.

When a module recognizes a Read command calling for a data transfer to the controller, it establishes data signals on the Read bus lines. When a controller recognizes a Write command calling for a data transfer to a module, it establishes data signals on the Write bus lines. In addition, regardless of whether there is transfer on the R or W lines, the module may transmit one bit of status information on the Response bus line.

Two timing signals, Strobes S1 and S2, are then generated in sequence on separate bus lines. The strobes are used to transfer data from the DATAWAY into modules (on Write commands) and into the controller (on Read commands). They may also initiate other actions within the controller and modules.

Whenever there is no DATAWAY operation in progress (indicated by the absence of the Busy signal) any module may generate a signal on its individual Look-at-Me line to indicate that it requires attention. Three common control signals are available



Block diagram and signal paths for 3 CAMAC modules and a Crate Controller.

at all stations, without requiring addressing by a command, in order to initialize all units (typically after switch-on), to Clear data registers, and to inhibit features such as data-taking.

2.1 DEFINITION OF COMMANDS

A command consists of signals on the DATAWAY lines which specify at least one module (by individual station number lines), a subsection of the module or modules (by the four subaddress bus lines), and the function to be performed (by the five function bus lines). The command signals are maintained for the full duration of the operation on the DATAWAY. They are accompanied by a signal on the Busy bus line which indicates to all units that a DATAWAY operation is in progress.

Station Number (N)

Each normal station is addressed by a signal on an individual station number line (N) which comes from a separate pin at the control station. The stations are numbered in decimal code from the lefthand end as viewed from the front, beginning with Station 1.

Subaddress (A8, A4, A2, A1)

Different sections of a module are addressed by signals on the four A bus lines. These signals are decoded in the module to select one of up to sixteen subaddresses, numbered in decimal from 0 to 15.

Function (F16, F4, F2, F1)

The function to be performed at the specified subaddress in the selected module or modules is defined by the signals on the five F bus lines. These signals are decoded in the module to select one of up to 32 functions, numbered in decimal from 0 to 31. The definitions of the 32 function codes are summarized in the DATAWAY Command Operations section.

Strobe Signals (S1 and S2)

Two strobe signals S1 and S2 are generated in sequence on separate bus lines. These signals are used to transfer information between plug-in units via the DATAWAY or to initiate operations within units. In either case the specific action is determined by the command present on the DATAWAY. Both strobes are generated during each DATAWAY command operation, and all plug-in units which accept information from the DATAWAY do so in response to these strobes. The first strobe S1 is used for actions which do not change the state of signals on the DATAWAY lines. All units which accept data from the DATAWAY in a Read operation, or in a Write operation do so in response to S1. The second strobe S2 is used to initiate any actions which may change the state of DATAWAY signals, for example, clearing a register whose output is connected to the DATAWAY.

2.2 DATA

A common parallel highway is used for all transfers. All information carried by the parallel highway is conveniently described as data, although it may be information concerned with status or control features in modules. Up to 24 bits may be transferred in parallel between the controller and the selected module. Independent lines (Read and Write) are provided for the two directions of transfer.

The Write Lines (W1-W24)

The controller or other common data source generates data signals on the W bus lines at the beginning of any "Write" operation. The W signals reach a steady state before S1, and are maintained until the end of the operation, unless modified by S2.

The Read Lines (R1-R24)

Data signals are set up on the R bus lines by the module as soon as a "Read" command is recognized. The R signals reach a steady state before S1, and are maintained for the full duration of the DATAWAY operation, unless the state of the data source is changed by S2. The controller or other common data receiver strobes the data from the R bus lines at the time of the Strobe S1.

2.3 STATUS INFORMATION

Status information is conveyed by signals on the Look-at-Me (L), Busy (B), and Response (Q) lines.

Look-at-Me (L)

This, like the N line, is an individual connection from each station to a separate pin at the control station. When there is no DATAWAY operation in progress (no B present) any plug-in unit may generate a signal on its L line to indicate that it requires attention. When B is present each L signal is gated off the DATAWAY line by the unit which generates it.

A Look-at-Me request can be reset by Clear Look-at-Me, initialize, or by the performance of the specific action which generated the request.

DATAWAY Busy (B)

The Busy signal is used to interlock various aspects of a system which can compete for the use of the DATAWAY. Specifically, it is generated during DATAWAY command or common control operations. Whenever N is present, B is present, and for the duration of B, all L signals are gated off the DATAWAY lines.

Response (Q)

The Q bus line is used during a DATAWAY operation to transmit a signal indicating the status of a selected feature of the module.

On all Read and Write commands the signal on the Q bus line remains static from the time the command is received until S2. For all other commands the signal on the Q bus line may change at any time.

2.4 COMMON CONTROLS

Common control signals operate on all modules connected to them without the need to be addressed separately by a command. In order to provide protection against spurious signals, the initialize (Z) and Clear (C) signals must be accompanied by Strobe S2.

Initialize (Z)

The initialize signal has absolute priority over all other signals or controls. It sets all units to a basic state by resetting all registers, whether data or control, to a defined state, and by resetting all L signals and disabling them where possible. Units which generate Z must also cause S2 and B to be generated. Modules which accept Z gate it with S2 as a protection against spurious signals on the Z line.

Inhibit (I)

The presence of this signal inhibits any activity (for example, data taking). It must either not change when B is present or have rise and fall times not less than 200 nsec.

Clear (C)

This command signal clears all registers or bistables connected to it. Units which generate C must also cause S2 and B to be generated. Modules which accept C gate it with S2 as a protection against spurious signals on the C line.

2.5 PRIVATE WIRING

Patch Leads (P1-P7)

Five pins (P1 to P5) on the 86-way socket at normal stations

are not prewired to DATAWAY lines but are freely available for local connections. At the control station, seven pins (P1-P7) are available. Signals on the patch pins must either remain static when B is present or have rise and fall times not less than 20 nsec.

2.6 DATAWAY COMMAND OPERATIONS

A Command is composed of signals on the Station Number line or lines, the Subaddress lines and the Function lines. It is accompanied by a signal on the Busy Line. In response to a command, data may be transferred on the Read or Write lines and one bit of status information on the Q line. The two Strobes S1 and S2 must be generated in each DATAWAY command operation to control its timing.

The order in which the commands are described below corresponds to the function codes set out in Table 1. In this table the term "register" is used for an addressable data source or receiver, without implying that it has a data storage property. The function codes allow the registers in a module to be divided into two distinct sets, known as Group 1 and Group 2. Thus it is possible to operate on more than the basic set of 16 registers selected by the four subaddress lines.

A common feature of all commands is that if the module has a Look-at-Me source which requests a specific command, then the performance of that command should reset the Look-at-Me source.

Read Commands (Function Codes 0-7)

Read commands are identified by the combination F16 = 0, F8 = 0 in the function code. They specify that information is to be transferred from a module to a controller via the R bus lines. Data signals are set up on the R bus lines by the module as soon as the "Read" command is recognized, and the appropriate status signal connected to the Q bus line. The R and Q signals reach a steady state before S1, and are maintained for the full duration of the DATAWAY command operation unless the state of the signal source is changed at S2. The controller or other common data receiver strobes the data from the R and Q bus lines at the time of the Strobe S1.

In order to facilitate reading by sequential addressing, all registers containing data (as opposed to control information) must have consecutive subaddresses starting at subaddress 0. At each of these subaddresses the module generates Q = 1 in response to the appropriate Read command. At the next subaddress in sequence (where there is not a data register) the response is Q = 0. At all remaining addresses the Q signal may be used to test any feature, subject to the general requirement that the Q signal must be static from the beginning of command until at least S2.

CODE 0, READ GROUP 1 REGISTER

This command selects, by subaddress, one register from the first group in the module and transfers the contents of this register to the controller. The contents of the register remain unchanged.

CODE 1, READ GROUP 2 REGISTER

Same as Code 0, except command selects register from the second group.

CODE 2, READ AND CLEAR GROUP 1 REGISTER

Same as Code 0, except the module register is cleared at time S2.

CODE 3, READ COMPLEMENT OF GROUP 1 REGISTER

Same as Code 0, except command transfers the complement of the contents of this register to the controller.

CODE 4-7

Unassigned at this time.

2.7 CONTROL COMMANDS (FUNCTION CODES 8-15)

Control commands are identified generally by F8 = 1 in the function code. They are divided into two groups by the state of F16, in this case F16 = 0. They specify that information is not transferred on either the R or W bus lines. However, information may be conveyed on the Q bus line in any of these commands. The signal on the Q bus line may change at any time but is strobed into the controller at time S1 and may (except in Code 8) be reset by Strobe 2.

CODE 8, TEST LOOK-AT-ME

This command selects a Look-at-Me source in the module and presents the state of this source on the Q bus line.

CODE 9, CLEAR GROUP 1 REGISTER

This command selects, by subaddress, a register from the first group in the module and clears the contents of this register.

CODE 10, CLEAR LOOK-AT-ME

Same as Code 8, except the Look-at-Me source is cleared at time S2.

CODE 11, CLEAR GROUP 2 REGISTER

Same as Code 9, except command selects register from the second group.

CODE 12-15

Unassigned at this time.

2.8 WRITE COMMANDS (FUNCTION CODES 16-23)

Write commands are identified by the combination F16 = 1, F8 = 0 in the function code. They specify that information is to be transferred from a controller to a module via the W bus line. The controller or other common data source generates data signals on the W bus lines at the beginning of the "Write" operation. The module connects the appropriate status signal to the Q bus line as soon as the command is recognized. The W and Q signals reach a steady state before S1 and are maintained for the full duration of the DATAWAY command operation unless the status of the signal source is changed at Strobe 2. In order to facilitate writing into registers by sequential addressing, all registers which are to contain data (as opposed to control information) have consecutive subaddress starting at subaddress 0. At each of these subaddresses, the module generates Q = 1 in response to the appropriate Write function. At the next subaddress in sequence (where there is not a data register), the response is Q = 0. At all remaining subaddresses the Q signal may be used to test any feature subject to the general requirement that the Q signal must be static from the beginning of the command until at least S2.

CODE 16, OVERWRITE GROUP 1 REGISTER

This command selects, by subaddress, one register in the first group in the module and sets the contents of this register to correspond with the data generated on the W bus lines by the controller.

CODE 17, OVERWRITE GROUP 2 REGISTER

Same as Code 16, except command selects a register in the second group.

CODE 18, SELECTIVE OVERWRITE GROUP 1 REGISTER

Same as Code 16, except a separate "mask" register defines which bits in the selected register are set.

CODE 19, SELECTIVE OVERWRITE GROUP 2 REGISTER

Same as Code 18, except command selects a register in the second group.

CODE 20 – 23

Unassigned at this time.

2.9 CONTROL COMMANDS (FUNCTION CODES 24-31)

Control commands are identified generally by F8 = 1 in the

function code. They are divided into two groups by the state of F16, in this case F16 = 1. They specify that information is not transferred on either the R or W bus lines. However, information may be conveyed by the Q bus line in any of these commands. The signal on the Q bus line is permitted to change at any time but is strobed into the controller at time S1 and may (except in Code 27) be reset by Strobe S2. Precautions must be taken to ensure that information is not lost due to Q signals appearing between S1 and S2.

CODE 24, DISABLE

This command selects, by subaddress, and disables a feature of the module; e.g., a Look-at-Me source or a data input.

CODE 25, INCREMENT PRESELECTED REGISTERS

This command adds one simultaneously to the contents of each register in one of 16 groups, defined by the subaddress.

CODE 26, ENABLE

This command enables the feature of the module selected by the subaddress, e.g., a Look-at-Me source or a data input.

CODE 27, TEST STATUS

This command selects, by subaddress, any feature of a module other than a source of a Look-at-Me request, and tests it by producing a response on the Q bus line.

CODE 28 — 31

Unassigned at this time.

CAMAC Reference Data

CAMAC FUNCTION CODES

CODE		FUNCTION SIGNALS					CODE
F( )	FUNCTION	F16	F8	F4	F2	F1	F( )
0	Read Group 1 Register	0	0	0	0	0	0
1	Read Group 2 Register	0	0	0	0	1	1
2	Read and Clear Group 1 Register	0	0	0	1	0	2
3	Read Complement of Group 1 Register	0	0	0	1	1	3
4	Non-standard	0	0	1	0	0	4
5	Reserved	0	0	1	0	1	5
6	Non-standard	0	0	1	1	0	6
7	Reserved	0	0	1	1	1	7
8	Test Look-at-Me	0	1	0	0	0	8
9	Clear Group 1 Register	0	1	0	0	1	9
10	Clear Look-at-Me	0	1	0	1	0	10
11	Clear Group 2 Register	0	1	0	1	1	11
12	Non-standard	0	1	1	0	0	12
13	Reserved	0	1	1	0	1	13
14	Non-standard	0	1	1	1	0	14
15	Reserved	0	1	1	1	1	15
16	Overwrite Group 1 Register	1	0	0	0	0	16
17	Overwrite Group 2 Register	1	0	0	0	1	17
18	Selective Set Group 1 Register	1	0	0	1	0	18
19	Selective Set Group 1 Register	1	0	0	1	1	19
20	Non-standard	1	0	1	0	0	20
21	Selective Clear Group 1 Register	1	0	1	0	1	21
22	Non-standard	1	0	1	1	0	22
23	Selective Clear Group 2 Register	1	0	1	1	1	23
24	Disable	1	1	0	0	0	24
25	Execute	1	1	0	0	1	25
26	Enable	1	1	0	1	0	26
27	Test Status	1	1	0	1	1	27
28	Non-standard	1	1	1	0	0	28
29	Reserved	1	1	1	0	1	29
30	Non-standard	1	1	1	1	0	30
31	Reserved	1	1	1	1	1	31

TABLE 1

2.10 DIGITAL SIGNAL STANDARDS ON THE DATAWAY

The potentials for the binary digital signals on the DATAWAY lines have been defined to correspond with those for compatible current sinking logic devices (e.g., the TTL and DTL series). The signal convention has, however, been inverted to be negative logic. The high state (more positive potential) corresponds to logic '0' and the low state (near ground potential) corresponds to logic '1'. Intrinsic OR outputs are thus available from the manufacturers' standard product range, and disconnected inputs go to the '0' state.

It is an essential feature of the DATAWAY that many units may have their signal outputs connected to the Read and Response lines. Outputs onto these lines therefore require intrinsic OR gates. The same principle is extended to other lines (Command, Write, etc.) in order to allow more than one control-line unit in a crate. The Inhibit line may be an exception, since its signals are shaped with a slow rise and fall if they change during DATAWAY operations.

VOLTAGE STANDARDS FOR DATAWAY SIGNALS

All DATAWAY Signals must conform to the voltage levels as follows:

Pull-up current sources for all DATAWAY bus lines are located in the crate controller (occupying the control station and at least one other station) so as to insure that there is one and only one current source per line. The minimum pull-up current when the DATAWAY line is at + 3.5 V is defined as 2.5 mA. If the controller generates DATAWAY signals at time intervals near the permitted minima, the pull-up current sources should preferably provide not less than 6 mA when the lines are at this potential. The pull-up for the N signals is located in the unit generating the signals, and for the L signals in the unit receiving the signals, so that the individual lines may be joined or grouped within these units if desired.

The N and L lines are effectively individual lines joining two units (a module and a controller). The Q and R lines generally will have many units generating the signals (say 20) with a few units (maximum four) receiving the signals. The remaining lines (W, A, F, S, B, Z, I, C) will have relatively few units generating each signal (often only one) with the possibility of many units receiving the signals.

TIMING OF DATAWAY SIGNALS

The sequence of events during a single DATAWAY operation is shown in the Timing Diagram on the following page. The shaded areas indicate the permitted variation of each signal between an ideal square signal and a signal whose transition across the appropriate signal threshold (0.8 V or 2.0 V) satisfies the conditions shown. The signal waveforms for the command and data lines apply to those lines, if any, which take up the '1' state. Other command and data lines may, of course, be in the '0' state during the operation.

The signals on the Busy line and the various signals constituting the command need not occur in exact synchronism, provided their envelope lies within the shaded areas of the diagram. Similar variation is permitted between the signals constituting the data. The broken line indicates the earliest time at which the data signals may change in response to S2.

Key points on these waveforms are indicated by t_0 - t_9, with the following significance:

Points t_0, t_3, t_6 represent the initiation of the negative-going of the Command, Strobe 1, and Strobe 2 signals, respectively. They are the times at which the signals would be received from an ideal DATAWAY with no capacitative loading.

Points t_9, t_5, t_8 represent similarly the initiation of the positive-going edges of the same signals.

Points t_2, t_{11} are the latest time at which the data source is permitted to initiate the negative-going and positive-going edges of the data signals.

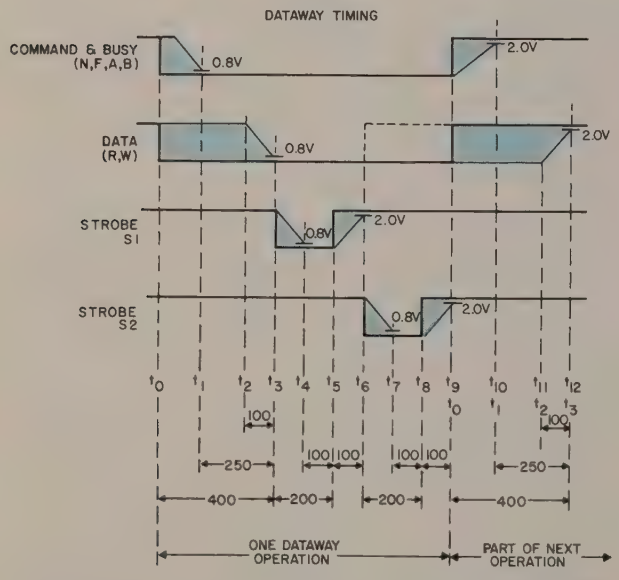
Points t_1, t_3, t_4, t_7 represent the latest times at which the received signals are permitted to reach a maintained '1' state, and therefore refer to the last negative-going transition across the +0.8 V threshold.

Points t_6, t_9, t_{10}, t_{12} represent the latest times at which the received signals are permitted to reach a maintained '0' state, and therefore refer to the last positive-going transition across the +2.0 V threshold.

Controllers must initiate the negative- and positive-going edges of the command and strobe signals at intervals not less than those defined by t_3, t_5, t_6, t_8, and t_9. Modules respond to the command within the most adverse value of $(t_1 - t_2)$; i.e., 100 nsec. The electrical characteristics of the DATAWAY and connections from it into units must allow signals to rise and fall within the minimum times for $(t_0 - t_1)$, $(t_2 - t_3)$ etc.

The next DATAWAY operation must not start before t_9.

The extreme case is shown in the Timing Diagram below with the next operation starting at t_9; $t_9 - t_{12}$ of one operation coincides with $t_0 - t_3$ of the next. The command and data signals of one operation may thus be removed while those of the next operation are being established. The Busy signal may be maintained continuously during a sequence of consecutive DATAWAY operations. Under suitable conditions any command or data signals of one operation may thus be removed while those of the next operation are being established. The Busy signal may be maintained continuously during a sequence of consecutive DATAWAY operations. Under suitable conditions any command or data signals which have the same state during successive operations may also be maintained. In the extreme case of successive operations with the same command and data, there could be a complete absence of signal transitions between t_0 and t_3.



Times given are maximum values in nsec timing of a Dataway operation.

SECTION 3: POWER SUPPLIES

The voltage tolerances and current loadings are specified in Table 2. The specified tolerances in voltage refer to the voltage measured at the contacts of the DATAWAY sockets and must be maintained under the worst combination of factors such as AC mains voltage and frequency, the maximum current loadings, temperature and the position in the crate of the socket under observation.

Note that the maximum currents stated in Table 2 below are subject to the overall restrictions as follows:

1. The current carried by any contact of the DATAWAY socket must not exceed 3 A.
2. The total power dissipated in a crate, without forced ventilation, must not exceed 200 W.
3. The power dissipation per single-width station should not, therefore, normally exceed 8 W. Under special circumstances, however, this rating may be increased to a maximum of 25 W, provided suitable precautions are taken to comply with total power dissipation and current loadings.

MAXIMUM CURRENT LOADS

SUPPLY VOLTAGE	VOLTAGE TOLERANCE	IN THE PLUG-IN (PER UNIT WIDTH) *See Notes 1 and 3 above.	IN THE CRATE *See Note 2 above
MANDATORY			
+24 V DC	±0.5%	1 A	6 A
+6 V DC	±2.5%	2 A	25 A
−6 V DC	±2.5%	2 A	25 A
−24 V DC	±0.5%	1 A	6 A
Additional (as required)			
+12 V DC	±0.5%		
+12 V DC			

Table 2

Bench Top 13 position Mini CAMAC Crate.

PIN ALLOCATION AT CONTROL STATION

(STATION 25)

Individual patch contact		P1	B	Busy	Bus line
Individual patch contact		P2	F16	Function	Bus line
Individual patch contact		P3	F8	Function	Bus line
Individual patch contact		P4	F4	Function	Bus line
Individual patch contact		P5	F2	Function	Bus line
Bus line	Command Accepted	X	F1	Function	Bus line
Bus line	Inhibit	I	A8	Subaddress	Bus line
Bus line	Clear	C	A4	Subaddress	Bus line
Individual patch contact		P6	A2	Subaddress	Bus line
Individual patch contact		P7	A1	Subaddress	Bus line
Bus line	Strobe 1	S1	Z	Initialize	Bus line
Bus line	Strobe 2	S2	Q	Response	Bus line
		L24	N24		
		L23	N23		
		L22	N22		
		L21	N21		
		L20	N20		
		L19	N19		
		L18	N18		
		L17	N17		
		L16	N16		
		L15	N15		
		L14	N14		
		L13	N13		
24 Individual Look-at-Me Lines		L12	N12	24 Individual Station	
L1 from Station 1, etc.		L11	N11	Number lines	
		L10	N10	N1 to Station 1, etc.	
		L9	N9		
		L8	N8		
		L7	N7		
		L6	N6		
		L5	N5		
		L4	N4		
		L3	N3		
		L2	N2		
		L1	N1		
	−12 V DC	−12	−24	−24 V DC	
		NC	−6	−6 V DC	
		NC	NC		
Power	Auxiliary −6 V supply	Y1	E	Clean Earth	Power
Bus lines	−12 V DC	+12	+24	+24 V DC	Bus lines
	Auxiliary +6 V supply	Y2	+6	+6 V DC	
	0 V (Power Return)	0	0	0 V (Power Return)	

TABLE 3a

PIN ALLOCATION AT NORMAL STATION

(STATIONS 1-24)

Bus line	Free Bus line	P1	B	Busy	Bus line
Bus line	Free Bus line	P2	F16	Function	Bus line
Individual patch contact		P3	F8	Function	Bus line
Individual patch contact		P4	F4	Function	Bus line
Individual patch contact		P5	F2	Function	Bus line
Bus line	Command Accepted	X	F1	Function	Bus line
Bus line	Inhibit	I	A8	Subaddress	Bus line
Bus line	Clear	C	A4	Subaddress	Bus line
Individual line	Station Number	N	A2	Subaddress	Bus line
Individual line	Look-At-Me	L	A1	Subaddress	Bus line
Bus line	Strobe 1	S1	Z	Initialize	Bus line
Bus line	Strobe 2	S2	Q	Response	Bus line
		W24	W23		
		W22	W21		
		W20	W19		
		W18	W17		
24 Write Bus Lines		W16	W15		
W1=LSB		W14	W13		
W24=MSB		W12	W11		
		W10	W9		
		W8	W7		
		W6	W5		
		W4	W3		
		W2	W1		
		R24	R23		
		R22	R21		
		R20	R19		
		R18	R17		
24 Read Bus Lines		R16	R15		
R1=LSB		R14	R13		
R24=MSB		R12	R11		
		R10	R9		
		R8	R7		
		R6	R5		
		R4	R3		
		R2	R1		
	−12 V DC	−12	−24	−24 V DC	
		NC	−6	−6 V DC	
		NC	NC		
Power	Auxiliary −6 V supply	Y1	E	Clean Earth	Power
Bus lines	−12 V DC	+12	+24	+24 V DC	Bus lines
	Auxiliary +6 V supply	Y2	+6	+6 V DC	
	0 V (Power Return)	0	0	0 V (Power Return)	

TABLE 3b

STANDARD DATAWAY USAGE

TITLE	DESIGNATION	CONTACTS	USE AT A MODULE
Command			
Station Number	N	1	Selects the module (Individual line from control station).
Sub-Address	A1, 2, 4, 8	4	Selects a section of the module.
Function	F1, 2, 4, 8, 16	5	Defines the function to be performed in the module.
Timing			
Strobe 1	S1	1	Controls first phase of operation. (Dataway signals may change).
Strobe 2	S2	1	Controls second phase (Dataway signals may change).
Data			
Write	W1-W24	24	Bring information to the module.
Read	R1-R24	24	Take information from the module.
Status			
Look-at-Me	L	1	Indicates request for service (Individual line to control station).
Busy	B	1	Indicates that a Dataway operation is in progress.
Response	Q	1	Indicates status of feature selected by command.
Command Accepted	X	1	Indicates that module is able to perform action required by the command.

TITLE	DESIGNATION	CONTACTS	USE AT A MODULE
Common Controls			Operate on all stations connected to them, no command required.
Initialize	Z	1	Sets module to a defined state. (accompanied by S2 and B).
Inhibit	I	1	Disables features for duration of signal.
Clear	C	1	Clears registers. (accompanied by S2 and B).
Non-Standard Connections			
Free bus-lines	P1, P2	2	For specified uses.
Patch contacts	P3-P5	3	For unspecified interconnections. No Dataway lines.
Mandatory Power Lines			
+24 V DC	+24	1	
+6 V DC	+6	1	
−6 V DC	−6	1	
−24 V DC	−24	1	
0 V	0	2	Power return
Additional Power Lines			Lines are reserved for the
+12 V DC	+12	1	following power supplies
−12 V DC	−12	1	Low current for indicators, etc.
Clean Earth	E	1	Reference for circuits requiring clean earth.
Reserved Y1, Y2	2		Reserved for future allocation.

TABLE 4

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